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Applicant (71) THOMAS & BETTS CORPORATION.

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Related Art (56)
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276737(38922/63) 04.20.
411119(8017/66) 04.20.

The following statement is a full description of this invention, including the best method of performing it known to us:

14968/73—L F. D. Atkinson, Government Printer, Canberra

X581-76-3D-14P.C.

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Field of the Invention:

The invention is directed to the field of electrical connections and principally to an electrical connector adaptable for use with both insulated and noninsulated electrical conductors such as copper, aluminum and other commonly employed electrical conductive materials having a variety of cross-sectional configurations.

Description of the Prior Art:

Electrical connectors according to the prior art generally comprised a conductor engaging means adjacent a suitably configured coupling means to provide an electrical connection between the connector and an adjacent conductor terminated therewith. Where the conductor was sheathed with insulating material, as for example a plastic coating or the like, it was generally necessary to remove a portion of the insulation therefrom to provide an uninsulated portion for engagement with the conductor engaging means of the connector, which was selectively proportioned

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to receive the uninsulated portion of the conductor while restricting the entrance therein of the insulated portion adjacent thereto. In the event the conductor was covered with a relatively thin overlay of insulated material, as is generally obtained in present insulated conductors, the conductor engaging means was insufficiently restrictive to prevent the inadvertent receipt therein of at least a portion of the insulated segment of the conductor, resulting in a defective electrical connection between the connector and the adjacent conductor, which was generally extremely difficult to detect after assembly.

The increasing use of aluminum conductors has caused further problems in this area, in that a tough, nonconductive oxide coating tends to form almost immediately on the surface of the conductor, seriously impairing the integrity of an electrical connection thereto. Attempts to provide an adequate connection by removing the surface oxide coating prior to engagement with the conductor engaging portion of a connector were generally unsuccessful either because a further oxide film would develop prior to assembly, or the resulting connection was insufficiently secure to insure permanent air tight engagement between the conductor engaging portion of the connector and the adjacent aluminum surface. Various methods have been employed to provide a suitable connector usable with either insulated copper conductors or aluminum conductors, which in one form utilized a conductor engaging portion having protruding teeth or piercing means thereon adapted to penetrate the insulation or oxide coating and engage the adjacent conductive portion of the conductor. Such devices have generally failed to provide a sufficiently

reliable electrical connection because the existing state of the art permitted little more than an empirical formation and arrangement of the teeth or piercing members upon the conductor engaging means, wherein either insufficient engagement was provided to assure an adequate electrical connection, or too great a penetration occurred, which tended to at least partially sever the conductor, resulting in both mechanical failure of the connection and overheating of the joint. Additionally, insufficient consideration was generally given to the use of such devices in conjunction with both solid and stranded conductors, and the differing problems associated therewith with respect to fracture resistance, optimum depth of penetration, and optimum contact area.

SUMMARY OF THE INVENTION:

The invention is directed to an improved electrical connector which overcomes the limitations noted above with respect to prior art devices by providing a calculably determinable plurality of selectively proportioned piercing members effectively disposed on a base member and arranged to enter and penetrate an adjacent conductor, resulting in an electrical connection therebetween which is more effective, efficient, secure and reliable than that furnished by such prior art devices. Each of the piercing members may be formed by either one of several suitable methods, such as by lancing, skiving or punching a portion of the base member on which said piercing members are disposed. Each of said piercing members generally comprise a first portion adjacent the base member and proportioned to either engage the insulated portion of an adjacent conductor or bridge the

spacing between the base member and the adjacent conductor surface in an uninsulated conductor, and a second portion substantially colinear with the first portion, extending therefrom, and selectively dimensioned to enter, penetrate and thereafter provide a predetermined conductor contact area defined generally by the surfaces thereof. The aggregate conductor contact area defined by the surfaces of the second portion is proportioned, in one embodiment, to at least equal the cross-sectional area of the conductor engageable therewith, thus assuring the required electrical contact therebetween, the depth of penetration of the piercing members being restrictively proportioned, within a predetermined range, to prevent mechanical injury to the conductor. In another embodiment, the piercing members are dimensionally proportioned to define an aggregate conductor contact area at least equal to the area of the immediately adjacent base member, from which they depend, thus providing a total area of contact with the conductive portion of an insulated conductor essentially equivalent to the surface area of the encompassed conductive portion, the number of piercing members and the depth of penetration being readily calculable and definable. Various configurations of the connector may be provided to permit its adaptability for use in conjunction with round, flat or square conductors of either copper, aluminum or other commonly employed conductive materials, each embodiment having specifically definable, and predeterminedly proportionable and arrangeable piercing members to insure optimum electrical and mechanical engagement with an associated conductor. It is therefore an object of this invention to provide an improved electrical connector.

Other objects and features of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode which has been contemplated for carrying it out.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the Drawings:

FIG. 1 is a side elevational view, in section, of a prior art electrical connector, showing an insulated conductor engaged therewith.

FIG. 2 is a perspective view of an electrical connector

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FIG. 3 is a perspective view of another embodiment of an electrical connector.

FIG. 4 is a perspective view of still another embodiment of an electrical connector.

FIG. 5 is a front elevational view of still a further embodiment of an electrical connector.

FIG. 6 is a perspective view of yet a further embodiment of an electrical connector, showing its engagement with a substantially square conductor.

FIG. 7 is a perspective view of still another embodiment of an electrical connector, showing its use in conjunction with a pair of relatively flat conductors.

FIG. 8 is a perspective view of a segment of the base portion of an electrical connector.

FIG. 9 is a perspective view of another embodiment of a segment of the base portion of an electrical connector.

FIG. 10 is a perspective view of a piercing member which may be employed in a connection of the invention.

FIG. 11 is a perspective view of another embodiment of a piercing member which may be employed in a connection of the invention.

FIG. 12 is a perspective view of still another embodiment of a piercing member which may be employed in a connection of the invention.

FIG. 13 is a perspective view of yet another

embodiment of a piercing member which may be employed in a connection of the invention.

FIG. 14 is a side elevational view, in section, showing the engagement between the piercing members of an electrical connector, and an enclosed insulated conductor to form a connection embodying the invention.

FIG. 15 is a side elevational view, in section, of another embodiment of the piercing members of an electrical connector constructed showing their engagement with an adjacent insulated conductor to form a connection embodying the invention.

FIG. 16 is a side elevational view, in section, of the piercing members of a prior art electrical connector penetrating the conductive portion of an adjacent insulated electrical conductor.

FIG. 17 is a cross-sectional view of the base portion and ajacent piercing members of an electrical connector as engaged about a generally round, stranded conductor to form a connection embodying the invention.

Similar elements are given similar reference characters in each of the respective drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Turning now to FIG. 1, there is shown a commonly employed prior art electrical connector 30 comprising a conductor engaging portion 32 adjacent one end thereof

and a coupling portion 34 adjacent the other end. The conductor engaging portion 32 of connector 30 is selectively contoured to provide a diametrically restrictive portion 40 adjacent the coupling portion 34 arranged to accept the bared end 38 of an insulated, generally round conductor such as 36. The remaining portion 42 of the conductor engaging portion 32 is diametrically enlarged to accept a portion of the unstripped insulated conductor 36, substantially as shown, thus providing a partial strain relief where desired. In the event the insulation 44 circumjacent the conductive portion 46 of conductor 36 is relatively thin, as is generally the case in presently available insulated conductors, there is a strong likelihood that a portion of the unstripped insulated conductor may inadvertently enter the restrictive portion 40 of connector 30, thereby preventing proper engagement between the conductive portion 46 of conductor 36 and connector 30, resulting in an insufficient electrical connection therebetween, as is clearly shown in FIG. 1.

Referring now to FIGS: 2,3,4,5,6, and 7, there are shown various embodiments of an electrical connector. These connectors are described to show the various manners in which connectors used in the connection embodying the invention maybe formed. In one embodiment, as illustrated in FIG. 2, the electrical connector 48 comprises a plurality of piercing members 50 selectively disposed on the generally arcuately formed base member 52 of connector 48 and arranged to enter and penetrate the conductive portion of a conductor (not shown) engageable therewithin. For illustrative purposes only, connector 48 is shown

as having a coupling portion 54 extending from its base member 52 and adapted to be secured to a further member (not shown)

by means of a stud or similar item inserted through an aperture 56 in coupling portion 54. In FIG. 3, there is shown an electrical connector 58 having a plurality of piercing members 60 selectively disposed on a base member 62 and depending inwardly in a manner similar to that shown in FIG. 2, but differing, however, in the particular arrangement thereof. Piercing members 60 of electrical connector 58 are selectively arranged to define essentially two longitudinally separated groupings, generally as shown, to permit engagement with predetermined portions of an adjacent conductor receivable within the conductor coupling portion 64 of connector 58. Extending from base member 62 is a spade-type coupling means 66, forming no part of the invention, but merely providing a convenient means for coupling connector 58 to a further member (not shown) where desirable. A further modification of an electrical connector 68 constructed in accordance with the concepts of the invention is shown in FIG. 4. Connector 68 comprises a plurality of piercing members 70 selectively disposed on a base member 72 and arranged to encompass, enter and penetrate the conductive portions of two or more conductors (not shown), each of which may be insulated or noninsulated, thereby providing an effective, rigidly secure splice-type connection between the conductors. Where it is desired to individually couple two or more relatively flat conductors, an electrical connector such as 74, as shown in FIG. 5, may be advantageously employed. Connector 74 comprises a serpentine-like base member 76 selectively formed to define a pair of spaced, conductor receiving apertures 78, 78' generally as shown. Extending

inwardly into each of the apertures 78, 78' are piercing members 80 in generally opposing relationship and selectively arranged to enter and penetrate an adjacent, substantially flat conductor (not shown) disposed within each of said apertures 78, 78', thus permitting the engagement of connector 74 to each conductor separately, base member 76 providing the electrical connecting path therebetween. In FIG. 7, there is shown an electrical connector 82, similar to connector 74 of FIG. 5 but arranged to provide a splice-type connection between adjacent, substantially flat conductors such as 84, 84' illustrated as disposed in generally overlapping relationship within the base member 86 of connector 82 and directly adjacent a plurality of selectively proportioned piercing members 88 depending inwardly from base member 86, and disposed in a prearranged manner thereon. Connector 48 of FIG. 2 may be modified to provide a connector such as 88, as shown in FIG. 6, to provide an electrical connection between a substantially square conductor such as 90, and said connector 88. A portion of the base member 92 of connector 88 has been cut away in FIG. 6 to illustrate the relative position of a few of a plurality of selectively proportioned piercing members 94 disposed thereon and arranged to enter and engage the conductive portion of conductor 90. In each of the embodiments described above with respect to FIGS. 2, 3, 4, 5, 6 and 7, a connection between the connector and an adjacent conductor is generally accomplished by urging the base member of the connector tightly against the adjacent surface of the conductor with sufficient force to advance the piercing members of the connector into

intimate engagement with the conductive portion of the associated conductor, each piercing member being selectively proportioned to penetrate the conductor a predetermined depth, as is more fully described below.

Referring now to FIG. 8, there is shown a plurality of selectively proportioned piercing members 96 disposed in prearranged order adjacent a portion of a base member 98 according to the concept of the invention. As illustrated, the piercing members are arranged in a generally regular diamond pattern, providing a predeterminable series of alternating piercing and non-piercing areas adapted to afford the required electrical and mechanical engagement with an adjacent conductor (not shown). The arrangement of piercing members 96 shown in FIG. 8 may be modified to define a pattern similar to that shown in FIG. 9, wherein said piercing members 96 are disposed on a portion of a base member 100 in generally spaced, parallel rows in oblique angular relationship with the longitudinal axis thereof. It should be understood that although only two patterns are shown, it is not intended that the invention be limited thereby, various other patterns and arrangements of selectively proportioned piercing members such as 96 being appropriately disposable on an associated adjacent base member to effect the required electrical and mechanical engagement with an adjacent conductor without departing from the spirit, and according to the teaching, of the invention.

Turning now to FIG. 10, there is shown a selectively proportioned piercing member 102 of an electrical connector which may be used in a connection embodying ~~constructed in accordance with the concepts of~~ the invention. Piercing member 102 is formed by lancing

a portion of the base member 104 as at 106 and deflecting the lanced portion outwardly generally normal to the plane thereof. Alternatively, as may be better seen in FIG. 11, a plurality of upstanding piercing members such as 108 may be formed in nest-like fashion about a generally centrally lanced portion 110 of base member 112. Further, each piercing member may be formed as by skiving or the like, as is clearly shown in FIG. 12, wherein a portion of base member 114 has been skived to form a multi-faced piercing member 116, thereby desirably increasing the conductor contact area per member. Where desirable and convenient, a portion of the base member 118, as shown in FIG. 13, may be partially deformed to define an upstanding, generally conical piercing member such as 120. It should be understood that although the specific shape of the piercing member is relatively unimportant, and may assume any one of the configurations shown, or any other desired shape, each is selectively proportioned, according to the concepts of the invention, to provide a predetermined depth of penetration and a calculably determinable aggregate conductor contact area relative to the particular dimensions and configurations of an adjacent conductor engageable therewith.

Turning now to FIGS. 14, 15 and 17, there are shown various embodiments of an electrical connector constructed in accordance with the concepts of the invention. In FIG. 14, electrical connector 121 comprises a predetermined number of piercing members 122 depending from a base portion 124 generally normal to the plane thereof, said piercing members 122 being shown embedded within the adjacent conductive portion 126 of an insulated conductor

128. Each selectively proportioned piercing member comprises a first portion 130 adjacent the base member 124, and engageable with an immediately adjacent insulating portion 132 of conductor 128, and a second portion 134 adjacent the first portion 130 and extending therefrom, said second portion 134 being arranged to enter and penetrate the conductive portion 126 of conductor 128 within the range of five per cent to fifty per cent of the minimum cross-sectional dimension thereof. The surfaces defining each of the second portions 134 comprise a conductor contact area dimensionally proportioned with respect to the predetermined number of piercing members 122, to provide an aggregate conductor contact area at least equal to, in one embodiment, the cross-sectional area of the conductive portion 126 of conductor 128. Thus, the number of piercing members required to provide a superior electrical connection between connector 121 and conductor 128 may be readily determined, in one embodiment, by dividing the total cross-sectional area of the conductive portion 126 of conductor 128 by the conductor contact area per piercing member. Alternatively, where the number of effective piercing members is known, the depth of penetration within the above specified range required to effect a proper electrical connection to the adjacent conductor may be conveniently determined from the above mentioned relationships of conductor contact area to conductor cross-sectional area. Additionally, in many instances certain mechanical considerations may dictate the minimum length of the conductor over which the connector may be satisfactorily engaged, to avoid undue stress or likelihood of fracture in the conductor, while

maintaining adequate electrical contact therewith. In FIG. 14, for example, the length of engagement of connector 121 with the adjacent segment of conductor 128 is dimensionally indicated by the reference letter A. Having predetermined the value of dimension A, on the basis of mechanical considerations, it becomes a simple matter, according to the concepts of the invention, to calculably determine the number of piercing members 122, each having a specified conductor contact area required to effect the desired electrical engagement between connector 121 and conductor 128. Where cost is a major factor, the length of engagement as heretofore described may be proportionately decreased, as, for example, to conserve connector material, while maintaining superior mechanical and electrical engagement, as may be more clearly seen with reference to FIG. 15. In FIG. 15, the base portion 136 of connector 138 is shown as extending longitudinally adjacent an insulated conductor 140 a length indicated by the reference letter B. Where such length B is relatively short with respect to the cross-sectional dimension of conductor 140, each of the piercing members 142 depending from the base portion 136 of connector 138 may be calculably proportioned to provide superior electrical engagement with conductor 140, it being necessary merely to insure that the aggregate conductor contact area defined by the product of the conductor area per piercing member 142 and the number of piercing members is at least equal to the cross-sectional dimension of the adjacent conductor 140. It will generally be found that where a relatively short engaging length B is employed, as exemplified in FIG. 15,

the depth of penetration of each of the piercing members 142 may be proportionately greater than that required where the engaging length is somewhat longer, as is shown, for example, in FIG. 14. However, where it is desired to maintain a relatively shallow depth of penetration, to avoid the possibility of undue stress or deformation of the adjacent conductor, the number of piercing members may be proportionately increased to account for the diminished conductor contact area per piercing member resulting generally from the decreased length thereof. For example, and specifically with reference to FIG. 17, the piercing members 144 of an electrical connector 146 constructed in accordance with the concepts of the invention, are shown engaged within the conductive portion 148 of a stranded insulated conductor 150. Generally, such engagement is attended by an inconsequential severing of a portion of the strands of conductor 150 immediately adjacent each of the piercing members 144, since any severed strands are effectively displaced by the electrically conductive material of the adjacent piercing member second portions, indicated generally at 152. Should too large a number of strands be severed, as for example where the depth of penetration of piercing members 144 exceeds fifty per cent of the diameter of the conductive portion 148 of stranded conductor 150, severe mechanical damage to the conductor 150 may result wherein the conductive portion 148 may fracture and split, as may be more clearly seen in FIG. 16, where there is shown a plurality of piercing members 153 extending from the base portion 154 of an electrical connector 156 and penetrating the conductive portion 158 of a stranded

conductor 160 to a depth in excess of fifty per cent of the diameter thereof. It is readily apparent that should conductor 160 undergo a fracture such as indicated at 162, the portion of conductor 160 to the right of FIG. 16 may be parted from the remaining portion adjacent connector 156, resulting in a complete failure of the connection.

It should be understood that in each case where there has been shown an insulated conductor usable in conjunction with an electrical connector constructed in accordance with the concepts of the invention, the connector is equally effective in providing an electrical connection to an uninsulated conductor in a similar manner, it being necessary merely to calculably determine the proportions of the piercing members of the connector to provide the required penetration and aggregate conductor contact area according to the principles disclosed herein. It should also be understood that the connector is readily adaptable for use in conjunction with aluminum conductors or any of the commonly employed alloys thereof, the piercing members being equally as effective in penetrating the naturally occurring oxide coating generally disposed on the surface thereof, and engaging the conductive portion therewithin.

Where desired, the aggregate conductor contact area defined by the piercing member second portions may be proportioned to at least equal the surface area of the adjacent base member portion encompassing said piercing members. For example, in FIG. 9 the surface area of the base member 100 immediately adjacent piercing members 96 may be defined by the product of the length L and the width W thereof. It should be readily apparent that the

conductor piercing second portion of each piercing member 96 may be appropriately proportioned in relation to a predetermined number of such members 96 so as to provide the required aggregate conductor contact area, the conductor contact area of each piercing member 96 being determined generally by the surface defining the piercing member second portion. Thus, the aggregate conductor contact area provided is at least equal to the conductor engaging area of an equivalently sized non-piercing connector engageable with the outer surface of a particular conductor, thereby eliminating the necessity for providing a clean, conductive surface adjacent the connector, as is necessary with a non-piercing connector, while providing an at least equivalent electrical and mechanical engagement. Although only two criteria have been disclosed with respect to the relationship of the aggregate conductor contact area with adjacent elements, other suitable relationships will be apparent to those skilled in the art, as, for example, providing an aggregate conductor contact area equivalent to approximately twice the cross-sectional area of the adjacent conductor to effect the purposes set forth above, without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An electrical connection of the type having a base member in contact with a conductor having a conductive portion for improvement comprising; a plurality of piercing members disposed on at least a portion of said base member and positioned adjacent the surface of said conductor; each of said piercing members having a first portion and a second portion, the first portion being disposed adjacent said base member and having a predetermined length selectively proportioned to bridge the space between the surface of said base member and the surface of said conductuve portion adjacent thereto, said second portion being aligned substantially colinear with said first portion, extending therefrom, and having a predetermined length calculably selected to permit its entrance into and penetration of said conductive portion a predetermined depth in the range of from five per cent to fifty per cent of the minimum cross-sectional dimension of said conductive portion, said second portion being further defined by at least one surface comprising a predetermined conductor contact area, the aggregate conductor contact area of said plurality of second portions being at least equal to the cross-sectional area of said conductor engaged therewith.

2. The connection as defined in Claim 1 wherein each of said piercing member second portions is defined by at least two surfaces, at least one of which is generally arcuate.

3. The connection as defined in Claim 2 wherein said base member is formed for disposition about a substantially round conductor, and wherein at least one of said piercing member second portion surfaces is generally planar.

4. The connection is defined in Claim 2, wherein said base member is formed for disposition about a substantially square conductor, and wherein at least one of said piercing member second portion surfaces is generally planar.

5. The connection as defined in Claim 2, wherein said base member is formed for disposition about a substantially flat conductor, and wherein at least one of said piercing member second portion surfaces is generally planar.

6. An electrical connection of the type having a base member disposed in contact with a conductor having a conductive portion; the improvement comprising: a predetermined number of piercing members disposed on at least a portion of said base member and positioned adjacent the surface of said conductor; each of said piercing members having a first portion and a second portion, said first portion being disposed adjacent said base member and having a predetermined length selectively proportioned to permit it to bridge the space between the surface of said base member and the surface of said conductive portion adjacent thereto, said second portion being aligned substantially colinear with

said first portion, extending therefrom, and having a predetermined length calculably selected to permit it to enter and penetrate said conductive portion ~~conductor~~ a predetermined depth in the range of from five per cent to fifty per cent of the minimum cross-sectional dimension thereof, said second portion being further defined by at least one surface comprising a predetermined conductor contact area, the aggregate conductor contact area of said plurality of second portions being at least equal to the surface area of said base portion encompassed by said piercing members.

7. The connection as defined in Claim 6, wherein said second portion of each of said piercing members is defined by at least two surfaces, at least one of which is generally arcuate.

8. The connection as defined in Claim 6, wherein at least one of said piercing members second portion surfaces is generally planar.

9. An insulation and oxide piercing electrical connection of the type having a base member disposed in contact with an insulated conductor, the improvement comprising: a plurality of insulation piercing members disposed on at least a portion of said base member and positioned adjacent the insulation of an insulated conductor, each of said insulation piercing members having a first portion and a second portion, said first portion being disposed adjacent said base member and having a predetermined length selectively proportioned to permit

it to enter the insulation of said insulated conductor adjacent thereto, said second portion being aligned substantially colinear with said first portion, extending therefrom, and having a predetermined length calculably selected to permit it to enter and penetrate the conductive portion of said insulated conductor a predetermined depth in the range of from five per cent to fifty per cent of the minimum cross-sectional dimension thereof, said second portion being further defined by at least one surface comprising a predetermined conductor contact area, the aggregate conductor contact area of said plurality of second portions being at least equal to the cross-sectional area of said conductor engaged therewith.

10. The connection as defined in Claim 9, wherein each of said insulation piercing member second portions is defined by at least two surfaces, at least one of which is generally arcuate.

11. The connection as defined in Claim 10, wherein said base member is formed for disposition about a substantially round insulated conductor, and wherein at least one of said piercing member second portion surfaces is generally planar.

12. The connection as defined in Claim 10, wherein said base member is formed for disposition about a substantially square insulated conductor, and wherein at least one of said piercing member second portion surfaces is generally planar.

13. An electrical connection substantially as hereinbefore described with reference to any one of Figures ~~1,~~ 6, 7, 14,15, ~~16~~ or 17 of the accompanying drawings or as modified by any one of Figures 2 to 5, or 8 to 13 of the accompanying drawings.

DATED THIS 21st DAY OF January 1974.

THOMAS & BETTS CORPORATION
By its Patent Attorneys:

CLEMENT HACK & CO.

Fellows Institute of Patent Attorneys of Australia.

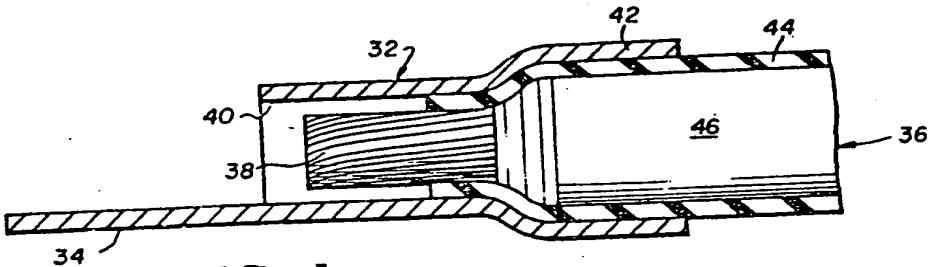

FIG. 1

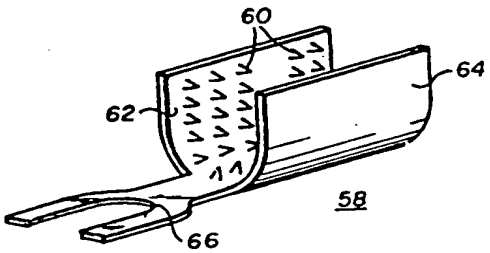

FIG. 2

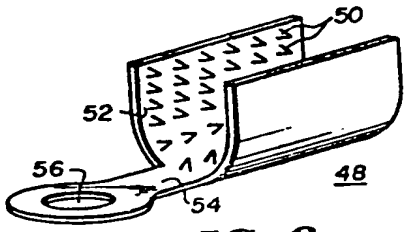

FIG. 3

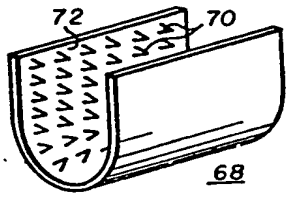

FIG. 4

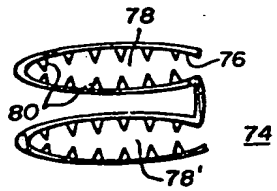

FIG. 5

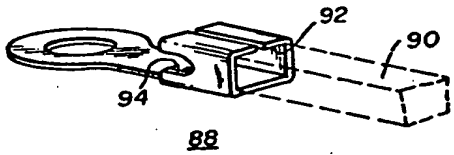

FIG. 6

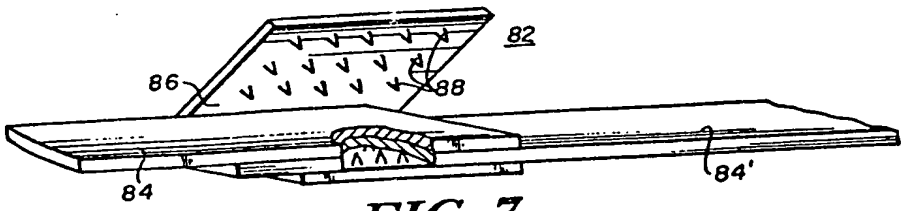

FIG. 7

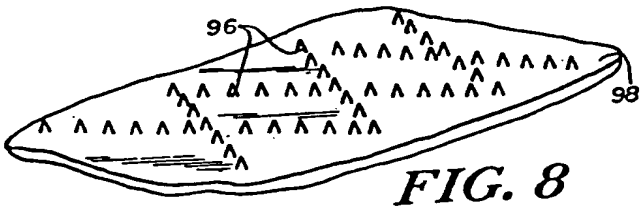

FIG. 8

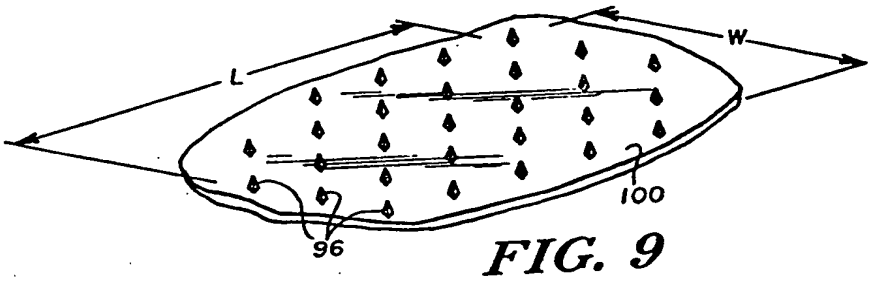

FIG. 9

FIG. 10

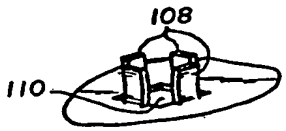

FIG. 11

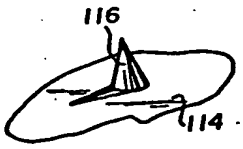

FIG. 12

FIG. 13

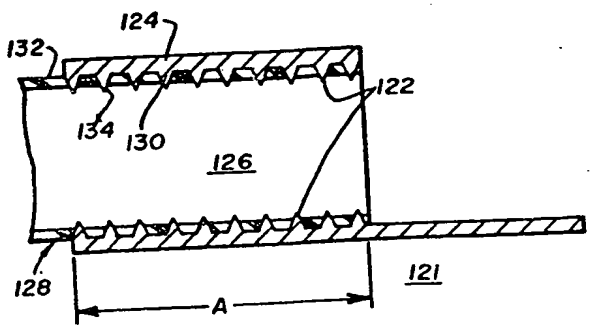

FIG. 14

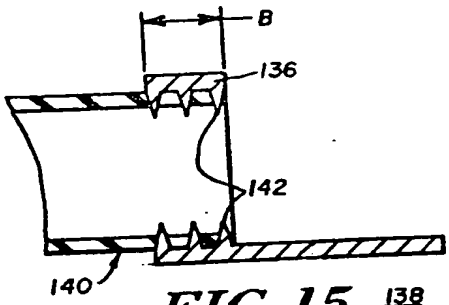

FIG. 15

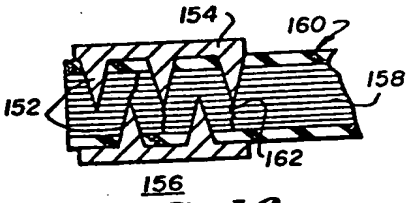

FIG. 16

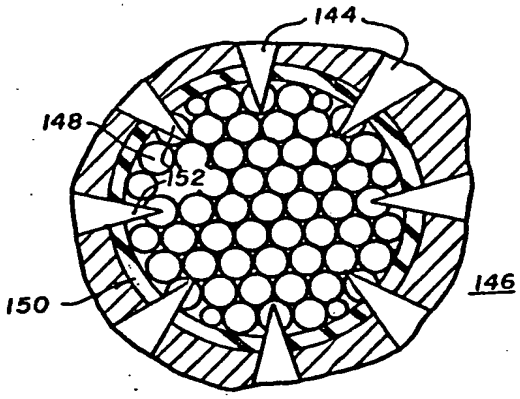

FIG. 17